

NODE=B083

 **$\Delta(1950)$  7/2<sup>+</sup>**

$I(J^P) = \frac{3}{2}(\frac{7}{2}^+)$  Status: \* \* \* \*

Most of the results published before 1975 were last included in our 1982 edition, Physics Letters **111B** 1 (1982). Some further obsolete results published before 1984 were last included in our 2006 edition, Journal of Physics, G **33** 1 (2006).

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 **$\Delta(1950)$  BREIT-WIGNER MASS**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>1915 to 1950 (<math>\approx</math> 1930) OUR ESTIMATE</b>			
1915 $\pm$ 6	ANISOVICH	12A	DPWA Multichannel
1921.3 $\pm$ 0.2	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1950 $\pm$ 15	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1913 $\pm$ 8	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1918 $\pm$ 1	SHRESTHA	12A	DPWA Multichannel
1928 $\pm$ 8	ANISOVICH	10	DPWA Multichannel
1923.3 $\pm$ 0.5	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1936 $\pm$ 5	VRANA	00	DPWA Multichannel
1947 $\pm$ 9	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
1921	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1940	LI	93	IPWA $\gamma N \rightarrow \pi N$
1945 $\pm$ 2	MANLEY	92	IPWA $\pi N \rightarrow \pi N & N\pi\pi$
1925 $\pm$ 20	CANDLIN	84	DPWA $\pi^+ p \rightarrow \Sigma^+ K^+$
1855.0 $^{+11.0}_{-10.0}$	CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
1925	<sup>1</sup> LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

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 **$\Delta(1950)$  BREIT-WIGNER WIDTH**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>235 to 335 (<math>\approx</math> 285) OUR ESTIMATE</b>			
246 $\pm$ 10	ANISOVICH	12A	DPWA Multichannel
271.1 $\pm$ 1.1	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
340 $\pm$ 50	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
224 $\pm$ 10	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
259 $\pm$ 4	SHRESTHA	12A	DPWA Multichannel
290 $\pm$ 14	ANISOVICH	10	DPWA Multichannel
278.2 $\pm$ 3.0	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
245 $\pm$ 12	VRANA	00	DPWA Multichannel
302 $\pm$ 9	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
232	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
306	LI	93	IPWA $\gamma N \rightarrow \pi N$
300 $\pm$ 7	MANLEY	92	IPWA $\pi N \rightarrow \pi N & N\pi\pi$
330 $\pm$ 40	CANDLIN	84	DPWA $\pi^+ p \rightarrow \Sigma^+ K^+$
157.2 $^{+22.0}_{-19.0}$	CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
240	<sup>1</sup> LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

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 **$\Delta(1950)$  POLE POSITION**

REAL PART VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>1870 to 1890 (<math>\approx</math> 1880) OUR ESTIMATE</b>			
1890 $\pm$ 4	ANISOVICH	12A	DPWA Multichannel
1876	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1878	<sup>2</sup> HOEHLER	93	ARGD $\pi N \rightarrow \pi N$
1890 $\pm$ 15	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1871	SHRESTHA	12A	DPWA Multichannel
1882 $\pm$ 8	ANISOVICH	10	DPWA Multichannel
1874	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1910	VRANA	00	DPWA Multichannel
1880	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1884	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90
1924 or 1924	<sup>3</sup> LONGACRE	78	IPWA $\pi N \rightarrow N\pi\pi$

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**-2×IMAGINARY PART**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>220 to 260 (≈ 240) OUR ESTIMATE</b>			
243± 8	ANISOVICH	12A	DPWA Multichannel
227	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
230	<sup>2</sup> HOEHLER	93	ARGD $\pi N \rightarrow \pi N$
260±40	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
220	SHRESTHA	12A	DPWA Multichannel
262±12	ANISOVICH	10	DPWA Multichannel
236	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
230	VRANA	00	DPWA Multichannel
236	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
238	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90
258 or 258	<sup>3</sup> LONGACRE	78	IPWA $\pi N \rightarrow N\pi\pi$

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**Δ(1950) ELASTIC POLE RESIDUE****MODULUS |r|**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
58±2	ANISOVICH	12A	DPWA Multichannel
53	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
47	HOEHLER	93	ARGD $\pi N \rightarrow \pi N$
50±7	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
57	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
54	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
61	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

NODE=B083220

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**PHASE θ**

VALUE (°)	DOCUMENT ID	TECN	COMMENT
-24±3	ANISOVICH	12A	DPWA Multichannel
-31	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
-32	HOEHLER	93	ARGD $\pi N \rightarrow \pi N$
-33±8	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-34	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
-17	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
-23	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

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**Δ(1950) INELASTIC POLE RESIDUE**The “normalized residue” is the residue divided by  $\Gamma_{pole}/2$ .**Normalized residue in  $N\pi \rightarrow \Delta(1950) \rightarrow \Sigma K$** 

MODULUS (%)	PHASE (°)	DOCUMENT ID	TECN	COMMENT
5±1	-65 ± 25	ANISOVICH	12A	DPWA Multichannel

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**Normalized residue in  $N\pi \rightarrow \Delta(1950) \rightarrow \Delta\pi, F\text{-wave}$** 

MODULUS (%)	PHASE (°)	DOCUMENT ID	TECN	COMMENT
12±4	12 ± 10	ANISOVICH	12A	DPWA Multichannel

NODE=B083RS2

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**Δ(1950) DECAY MODES**

The following branching fractions are our estimates, not fits or averages.

Mode	Fraction ( $\Gamma_i/\Gamma$ )
$\Gamma_1 N\pi$	35–45 %
$\Gamma_2 \Sigma K$	
$\Gamma_3 N\pi\pi$	
$\Gamma_4 \Delta\pi$	20–30 %
$\Gamma_5 \Delta(1232)\pi, F\text{-wave}$	
$\Gamma_6 \Delta(1232)\pi, H\text{-wave}$	

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DESIG=1;OUR EST

DESIG=2

DESIG=171;OUR EST

DESIG=181;OUR EST

DESIG=3

DESIG=4

$\Gamma_7$	$N\rho$	$<10\%$	DESIG=182;OUR EST
$\Gamma_8$	$N\rho, S=1/2, F\text{-wave}$		DESIG=5
$\Gamma_9$	$N\rho, S=3/2, F\text{-wave}$		DESIG=6
$\Gamma_{10}$	$N\gamma$	0.08–0.13 %	DESIG=185;OUR EST
$\Gamma_{11}$	$N\gamma, \text{ helicity}=1/2$	0.03–0.055 %	DESIG=8;OUR EST
$\Gamma_{12}$	$N\gamma, \text{ helicity}=3/2$	0.05–0.075 %	DESIG=9;OUR EST

 **$\Delta(1950)$  BRANCHING RATIOS**

$\Gamma(N\pi)/\Gamma_{\text{total}}$		$\Gamma_1/\Gamma$
<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u> <u>COMMENT</u>
<b>35 to 45 OUR ESTIMATE</b>		
45 ± 2	ANISOVICH	12A DPWA Multichannel
47.1 ± 0.1	ARNDT	06 DPWA $\pi N \rightarrow \pi N, \eta N$
39 ± 4	CUTKOSKY	80 IPWA $\pi N \rightarrow \pi N$
38 ± 2	HOEHLER	79 IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •		
45.6 ± 0.4	SHRESTHA	12A DPWA Multichannel
44 ± 8	ANISOVICH	10 DPWA Multichannel
48.0 ± 0.2	ARNDT	04 DPWA $\pi N \rightarrow \pi N, \eta N$
44 ± 1	VRANA	00 DPWA Multichannel
49	ARNDT	95 DPWA $\pi N \rightarrow N\pi$
38 ± 1	MANLEY	92 IPWA $\pi N \rightarrow \pi N & N\pi\pi$
44	CHEW	80 BPWA $\pi^+ p \rightarrow \pi^+ p$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1950) \rightarrow \Sigma K$		$(\Gamma_1\Gamma_2)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u> <u>COMMENT</u>
-0.053 ± 0.005	CANDLIN	84 DPWA $\pi^+ p \rightarrow \Sigma^+ K^+$

$\Gamma(\Sigma K)/\Gamma_{\text{total}}$		$\Gamma_2/\Gamma$
<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u> <u>COMMENT</u>
0.4 ± 0.1	ANISOVICH	12A DPWA Multichannel

Note: Signs of couplings from  $\pi N \rightarrow N\pi\pi$  analyses were changed in the 1986 edition to agree with the baryon-first convention; the overall phase ambiguity is resolved by choosing a negative sign for the  $\Delta(1620) S_{31}$  coupling to  $\Delta(1232)\pi$ .

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1950) \rightarrow \Delta(1232)\pi, F\text{-wave}$		$(\Gamma_1\Gamma_5)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u> <u>COMMENT</u>
<b>+0.28 to +0.32 OUR ESTIMATE</b>		
+0.32	<sup>1</sup> LONGACRE	75 IPWA $\pi N \rightarrow N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •		
+0.27 ± 0.02	MANLEY	92 IPWA $\pi N \rightarrow \pi N & N\pi\pi$

$\Gamma(\Delta(1232)\pi, F\text{-wave})/\Gamma_{\text{total}}$		$\Gamma_5/\Gamma$
<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u> <u>COMMENT</u>
2.8 ± 1.4	ANISOVICH	12A DPWA Multichannel
36 ± 1	VRANA	00 DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •		
8 ± 1	SHRESTHA	12A DPWA Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1950) \rightarrow N\rho, S=3/2, F\text{-wave}$		$(\Gamma_1\Gamma_9)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u> <u>COMMENT</u>
+0.24	<sup>1</sup> LONGACRE	75 IPWA $\pi N \rightarrow N\pi\pi$

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NODE=B083R2  
NODE=B083R2

NODE=B083R01  
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NODE=B083310

NODE=B083R3  
NODE=B083R3  
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NODE=B083R6  
NODE=B083R6

NODE=B083R4  
NODE=B083R4

## $\Delta(1950)$ PHOTON DECAY AMPLITUDES

Papers on  $\gamma N$  amplitudes predating 1981 may be found in our 2006 edition,  
Journal of Physics, G **33** 1 (2006).

### $\Delta(1950) \rightarrow N\gamma$ , helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV <sup>-1/2</sup> )	DOCUMENT ID	TECN	COMMENT
<b>-0.076±0.012 OUR ESTIMATE</b>			
0.071±0.004	ANISOVICH	12A	DPWA Multichannel
-0.083±0.004	WORKMAN	12A	DPWA $\gamma N \rightarrow N\pi$
-0.068±0.007	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-0.065±0.001	SHRESTHA	12A	DPWA Multichannel
-0.083±0.008	ANISOVICH	10	DPWA Multichannel
-0.094	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
-0.079±0.006	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
-0.102±0.003	LI	93	IPWA $\gamma N \rightarrow \pi N$

NODE=B083235

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NODE=B083A1

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→ UNCHECKED ←

### $\Delta(1950) \rightarrow N\gamma$ , helicity-3/2 amplitude $A_{3/2}$

VALUE (GeV <sup>-1/2</sup> )	DOCUMENT ID	TECN	COMMENT
<b>-0.097±0.010 OUR ESTIMATE</b>			
-0.094±0.005	ANISOVICH	12A	DPWA Multichannel
-0.096±0.004	WORKMAN	12A	DPWA $\gamma N \rightarrow N\pi$
-0.094±0.016	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-0.083±0.001	SHRESTHA	12A	DPWA Multichannel
-0.092±0.008	ANISOVICH	10	DPWA Multichannel
-0.121	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
-0.103±0.006	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
-0.115±0.003	LI	93	IPWA $\gamma N \rightarrow \pi N$

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### $\Delta(1950)$ FOOTNOTES

- 1 From method II of LONGACRE 75: eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.
- 2 See HOEHLER 93 for a detailed discussion of the evidence for and the pole parameters of  $N$  and  $\Delta$  resonances as determined from Argand diagrams of  $\pi N$  elastic partial-wave amplitudes and from plots of the speeds with which the amplitudes traverse the diagrams.
- 3 LONGACRE 78 values are from a search for poles in the unitarized T-matrix. The first (second) value uses, in addition to  $\pi N \rightarrow N\pi\pi$  data, elastic amplitudes from a Saclay (CERN) partial-wave analysis.

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NODE=B083;LINKAGE=L5

NODE=B010;LINKAGE=H9

NODE=B083;LINKAGE=L8

### $\Delta(1950)$ REFERENCES

ANISOVICH	12A	EPJ A48 15	A.V. Anisovich <i>et al.</i>	(BONN, PNPI)
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)
WORKMAN	12A	PR C86 015202	R. Workman <i>et al.</i>	(GWU)
ANISOVICH	10	EPJ A44 203	A.V. Anisovich <i>et al.</i>	(BONN, PNPI)
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)
ARNDT	06	PR C74 045205	R.A. Arndt <i>et al.</i>	(GWU)
PDG	06	JPG 33 1	W.-M. Yao <i>et al.</i>	(PDG Collab.)
ARNDT	04	PR C69 035213	R.A. Arndt <i>et al.</i>	(GWU, TRIU)
VRANA	00	PRPL 328 181	T.P. Vrana, S.A. Dytman,, T.-S.H. Lee	(PITT+)
ARNDT	96	PR C53 430	R.A. Arndt, I.I. Strakovsky, R.L. Workman	(VPI)
ARNDT	95	PR C52 2120	R.A. Arndt <i>et al.</i>	(VPI, BRCO)
HOEHLER	93	$\pi N$ Newsletter 9 1	G. Hohler	(KARL)
LI	93	PR C47 2759	Z.J. Li <i>et al.</i>	(VPI)
MANLEY	92	PR D45 4002	D.M. Manley, E.M. Saleski	(KSA) IJP
Also		PR D30 904	D.M. Manley <i>et al.</i>	(VPI)
ARNDT	91	PR D43 2131	R.A. Arndt <i>et al.</i>	(VPI, TELE) IJP
CANDLIN	84	NP B238 477	D.J. Candlin <i>et al.</i>	(EDIN, RAL, LOWC)
PDG	82	PL 11B 1	M. Roos <i>et al.</i>	(HELS, CIT, CERN)
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)
Also		NP B197 365	K. Fujii <i>et al.</i>	(NAGO)
CHEW	80	Toronto Conf. 123	D.M. Chew	(LBL) IJP
CUTKOSKY	80	Toronto Conf. 19	R.E. Cutkosky <i>et al.</i>	(CMU, LBL) IJP
Also		PR D20 2839	R.E. Cutkosky <i>et al.</i>	(CMU, LBL) IJP
HOEHLER	79	PDAT 12-1	G. Hohler <i>et al.</i>	(KARLT) IJP
Also		Toronto Conf. 3	R. Koch	(KARLT) IJP
LONGACRE	78	PR D17 1795	R.S. Longacre <i>et al.</i>	(LBL, SLAC)
LONGACRE	75	PL 55B 415	R.S. Longacre <i>et al.</i>	(LBL, SLAC) IJP

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